Digital Textile Printing

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Abstract

As a result of the downturn in the last years and the economic pressure two major changes are seen in the global textile printing market: more individual designs and shorter run lengths. To reduce sampling costs the ink jet printing technology is penetrating into textile printing.

The economics of ink jet printing are the main driver of this technique. The costs per m² for ink jet printing are lower for short run lengths than in traditional screen printing. This switches for longer runs. The turning point is an individual factor for every textile printing company.

End user require certain coloration and handling properties for production goods as well as for samples. Ink jet inks have to meet these criteria in combination with the right pre- or post-treatment systems. The choice of colorants for textile inks and the performance on the fabric are different from the graphic industry.

Multi-step processing systems are reactive and acid dye inks. The easier single-step systems are disperse dye and pigment ink systems. BASF established inks based on all four colorants.

The future of the ink jet technology in textile printing for sampling and production depends on the two factors, costs per m² and running speed.

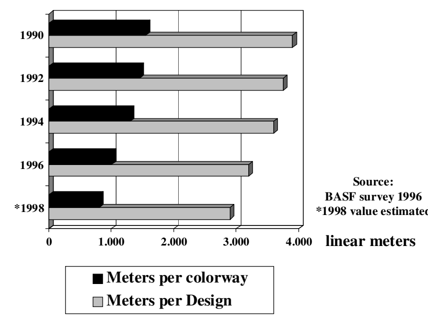
Changes in the Global Textile Printing Market

During the years 1996-1998, the total volume of textiles printed has declined by ~5% worldwide. A cyclical upturn in fashion towards printed rather than plain dyed goods has not happened since the high levels of demand experienced during the late 1980s.

This lower demand for printed articles has brought about significant changes in the industry. The price of printed goods has fallen and the industry has moved to developing, lower labor cost markets. The business has not been replaced in the traditional printing markets in Europe and North America, due to the corresponding drop in overall demand. This has resulted in a number of factory closures, with the likelihood that the business will not return in the future.

The recent Asian crisis of 1997/1998 has put additional pressure on the Far East economy resulting in a global struggle for textile printers to survive in this increasingly competitive industry.

Average running meters



The graph shows the steady decline in running meters during the years 1990 to 1998. The printing lengths of color-ways have also declined. It is now more typical to be printing designs under 1,000m lots.

Only recently signs for an upturn in fashion for printed textiles are coming from Asia. If this trend will be transported to America and Europe is an open question.

Many printers are now forced to reconsider their processing techniques and re-evaluate the way they operate. In some cases, this has involved becoming more specialized and finding new ways of differentiating themselves from the competition. This has led to two major changes in textile printing:

- A trend to more original and exclusive designs – those printers offering a differentiated product, either through design or by printing specialized fabrics have been generally able to compete better.
- Shorter run lengths – fashion seasons change on a regular basis and in some cases there can be as many as 5-6 changes in one year. The ability to switch designs quickly has become a prerequisite of the modern printer who is now finding that the length of each design is becoming shorter and shorter.

Both however, more exclusivity and shorter run lengths, put increasing pressure on the textile printer in terms of cost. Especially the sampling costs are rising.

Reducing the Cost of Sampling

For every new design and for each color one individual screen is necessary. Making these screens is associated with high costs and is time consuming. In fact, more than half of the total production time is spent on engraving and sampling alone. The printer takes a risk every time he engraves screens, as only 40-60% of any new patterns generates enough production orders to cover the costs incurred. With shorter run lengths, machinery downtime is also extended due to frequent change over of designs and incoming production orders will then cover less and less of these sampling costs.

One solution to minimizing the costs associated with sampling is to remove the screens from the sampling stage altogether. This has been achieved in recent years by the implementation of digital printing processes.

In order for this technique to replace screen production in sampling it had to meet certain criteria: Equivalent results by digital and conventional production; simple, reliable technology requiring minimal maintenance; reproducible printing results and a significant reduction in sampling costs. The most promising digital print technology to fill the role is ink jet. However, considerable development of this technology was necessary to convert what was essentially office equipment into something that would work in an industrial environment on textiles.

Ink jet printing has found an increasing application in the printing of textiles. It has shown considerable benefit in the aspects of sampling and more recently in the production of printed textiles.

Ink Jet Production

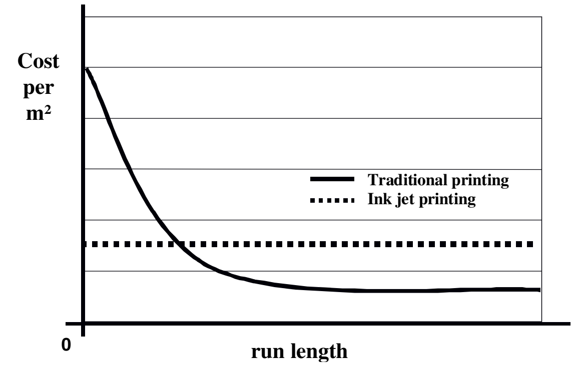
As the speed of ink jet printing has increased, the possibilities of printing finished articles have become increasingly important. Ink jet can be used to produce differentiated and unique printed articles. Designs that can never be achieved in normal print production can be easily done. For example, in traditional processing the number of colors used is restricted. Normally, only 24 colors are available in a rotary screen printer and although more can be printed using automatic table printing, the number of colors does not usually exceed 40. With ink jet printing, there is no limit to the number of colors you can use in a design giving enormous potential in the type of prints that can be produced.

The fact that screens are not necessary anymore gives a great deal of flexibility in setting up new designs. The idea once as a design on the computer is seen on fabrics instantaneously. The whole system is extremely compact bringing what is essentially an industrial scale process to an office environment. This has great appeal for the retail sector where the idea of customizing cloths for customers becomes a distinct possibility.

Economics of Ink Jet Printing in Textile

The margins in the textile printing industry are low. Reducing costs is a survival issue for the whole industry. In order for the ink jet technology to be successful it has to provide the textile printer with an economical benefit. Hardly anyone in textile will use digital technologies just because of convincing technical advantages. Costs are decisive in the first place.

Economics of digital vs. traditional printing



In traditional screen printing the investment costs for the machinery are high whereas the running costs are low. In ink jet printing this is just the opposite: low investment and high running costs. The costs for one m² textile printed traditionally are going down with longer run lengths. In ink jet costs are nearly the same for shorter and longer run lengths. There is a point where the costs for traditional and digital printing are the same. The exact data of this turning point have to be defined individually by the textile printer according to his set-up.

End User Requirements

In order for ink jet to find an application in either sampling or production of printed fabrics, the process has to mimic that of traditional technology in terms of the final end user requirements. Several of the major end user requirements are now detailed.

When providing samples for textile printers, who are then going to print the bulk of the design by traditional processing methods, it is important that the sample resembles closely the final fabric print. The following criteria must be taken into account:

color reproduction – the color must be a near perfect match; the sample must not appear duller or more muted

handle of fabric – the same fabric and finish must be used in sampling as is used in production

Fastness properties are a factor in sampling and production. The user expects for both a certain levels of fastness to washing and perspiration. Especially improvements in the detergent technology have resulted in difficulties meeting fastness standards. Although light fastness has some importance for apparel fabrics, it is not as important as for fabrics to be used outdoors or in places where they are exposed for long periods of time in direct sunlight. Ink jet is now commonly used to print banners, flags and other items that are traditionally exposed to light for long periods of time. The ability for the shade to remain unfading with exposure to light and sometimes extreme weather conditions is extremely important.

For some designers it may be possible to ink jet print the design on paper or even on a coated textile. In this case the textile printer would still require the fastness properties on the sample stage before committing to bulk processing. Only if the above criteria can be met by ink jet printing without printing samples by traditional methods and going straight to production, the time and cost savings are realized.

Ink Jet Ink Development - Colorants

In order for ink jet printed fabrics to meet the many demands of the end user, considerable efforts had to be put in the development of ink jet inks and the way those inks are then fixed onto the fiber. Most of the fastness properties described are determined by the particular chromophore of the dye or pigment and the method or means by which the dye is 'fixed' to the fiber. It is the breakage of this link to the fiber, or the destruction of the chromophore itself that determines the fading of an ink system.

In traditional processing, the dyestuffs used to color a substrate are determined by a series of criteria:

- end use fastness requirements, e.g. wash, light
- fiber type:
  synthetic, e.g. polyester, polyamide
  cellulosic, e.g. cotton, viscose
  fiber blends, e.g. polyester/cotton

If the final fabric is to be produced by ink jet, the criteria for colorant choice in the inks is the same as for traditional processing. The following table gives the primary and secondary coloration choice for the various different substrates that are traditionally printed.

Fiber	Primary coloration	Secondary coloration
Cotton	Pigment	reactive, vats
Viscose	Reactive	vats, pigments
Polyester	Disperse	
Wool/Silk/PA	acid, pre-metallized	Reactive
Polyester blends	Pigments	Reactive or vat mixtures with disperse dyes

Over the years, inks and their systems of application have been developed based on the above coloration principles. This means that it is likely that fastness and end user criteria are met and also the technology is not too dissimilar if, as in sampling, an imitation of the production fabric is required.

The main demand of ink jet printing for textiles will be equivalent colorant choices to those detailed in the table above to enable the textile printer to mimic what is current industry standard.

Multi-Step vs. Single-Step Processing

Generally, the optimum ink jet processing will follow roughly the same processing routes as with traditional screen printing. This has meant, however, that complicated systems of pre- and post-treatment often have to be employed in order to make use of the ink jet printing technology in textile.

Printing with reactive and acid dye inks generally involves pre- and post-treatment in order for the dyestuff to fix onto the fabric. This is a multi-step process with a substantial degree of complexity.

Printing with pigment or disperse dye inks is usually a simple single-step process. Online in one path these colorants can be printed and fixed to the fiber.

Ink Jet Printing with Reactive Dye Inks

Reactive dye based inks have been used for many years in ink jet processing, mainly because of the ease of getting them into suitable ink formulations due to their water solubility. The dye reacts with the cellulose to form covalent chemical bonds. These bonds give the reactive dyes their high levels of fastness to washing. In order to achieve full chemical reaction, alkali and heat are required. In ink jet the alkali must be applied by a pre-treatment process as it interferes with the reactive dyes and the nozzle components if put in the ink itself. The heat is applied after printing by a steam or hot air fixation process. A separate wash process must also wash off any unfixed reactive dye.

The reactive dye inks from BASF are based on common reactive dyes used in screen printing and therefore the color gamut and printing properties are equivalent providing the correct application procedure is followed.

Ink Jet Printing with Acid Dye Inks

Acid dyes are used to print wool, silk and polyamide fibers. Although only a small sector, it is still quite important for ink jet. A pre-treatment is generally necessary to prevent wicking of the ink on the fabric. A post-treatment, such as steaming is necessary in order to get fixation and a separate wash-off process ensures removal of unfixed dye. The new range of acid dye inks from BASF meets the high standard of the industry.

Ink Jet Printing with Disperse Dye Inks

Disperse dyes are the main printing system for polyester. The Bafixan® inks from BASF are based on disperse dyes that can be ink jet printed directly onto substrates and also printed onto paper and then transferred to textile using a heat press. High temperature steam is generally used online to fix the dye after direct printing in an easy single-step process The Bafixan inks have already been used extensively in the production of flags and banners by ink jet technology.

Ink Jet Printing with Pigment Inks

Pigment printing accounts for almost half of all printed textiles and is therefore an important coloration group. The colored pigment is bound to the substrate using a binder system. In screen printing this binder is put in the printing paste. In ink jet it must be applied either in the ink, by separate nozzle system or by application after ink jet printing. The Helizarin® inks from BASF have been specially formulated so that they can be easily applied by ink jet. Based on our knowledge in pigment textile printing developed over decades these pigment inks comprise all the important features of an textile ink like color strength and gamut, run ability and fastness properties when the correct application procedure is followed. These inks run on piezo as well as on thermal print head technology. They can be applied to many different substrates and the application route, which does not employ a pre-treatment or a washing process, is shorter than that of reactive based inks.

The Future

Ink jet has already found its way into the textile printing process for use in sampling and for some short run length production. The future of ink jet in textile printing depends on two factors: costs per m^2 and the speed of the printer.

As ink jet printing speed increases, it is anticipated that ink jet will account for even more production processing due to the distinct advantages over screen printing. But running costs have to come down to establish ink jet in real bulk production.

As a market leader in the supply of chemicals and colorants to the textile printer today, BASF will continue to provide simple and effective systems that enable the textile printer to use ink jet printing in combination with or instead of traditional processing techniques. The textile printer will have confidence that the dyes, pigments and auxiliaries used to formulate inks will give identical results to those used in conventional production, and that industry standards will be met when it comes to performance demanded by the end user.

Biography

Juergen Weiser received his PhD degree in chemistry from Heidelberg University. After working at UCLA as a postdoctoral fellow he joined BASF in 1988. He held various positions in research, production and marketing before he took responsibility of the ink jet team in 1999.